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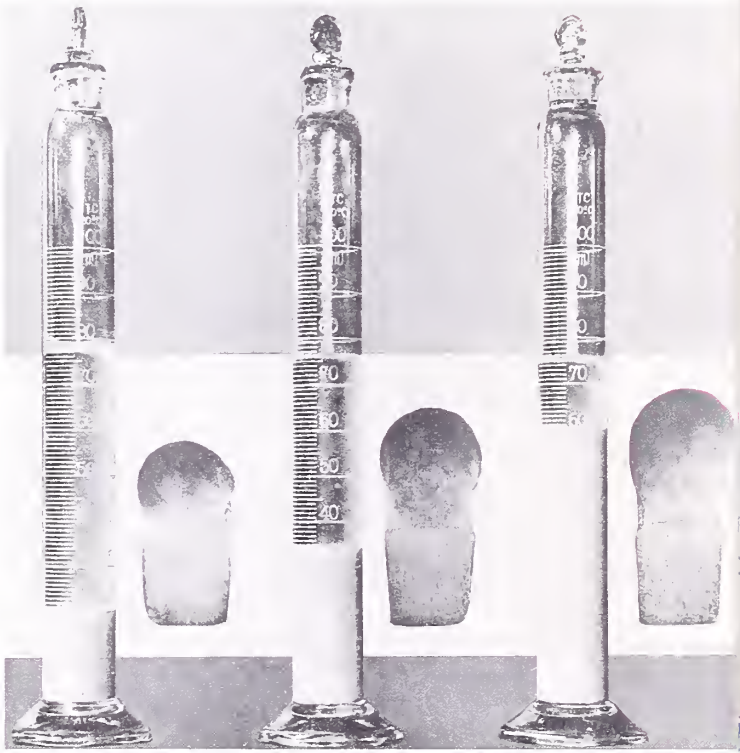
SEDIMENTATION

AS A MEASURE OF WHEAT QUALITY

1962 CROP



U.S. DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Grain Division

PREFACE

The investigation described in this report was conducted by the U. S. Department of Agriculture using data supplied by Doty Laboratories, Inc., of North Kansas City, Missouri. The investigation was supported by funds provided jointly by Doty Laboratories, Great Plains Wheat, Inc., and the U. S. Department of Agriculture.

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SEDIMENTATION AS A MEASURE OF WHEAT QUALITY -- 1962 CROP

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SUMMARY

In a broad survey of the quality of the U. S. 1962 hard red winter and hard red spring wheat crops covering 31 areas of production, wheat sedimentation was found to be superior to protein content and to each of the important farinogram characteristics as a means of predicting bread-baking quality. Wheat sedimentation value was also found to be superior to wheat protein content as a means of predicting mixing time, mixing tolerance, M.T.I. value, and valorimeter value as determined by the farinograph. The superiority of sedimentation over protein and over all farinogram characteristics as a measure of bread-baking quality was found to be quite great in most areas both for hard red winter wheat and hard red spring wheat, but especially so in the case of hard red spring wheat.

INTRODUCTION

Sedimentation value was used as a basis for determining loan value premiums to farmers in connection with the Government's wheat price support program for the first time in 1962.

For this reason there is much interest in how well the sedimentation test reflected the quality of the 1962 hard wheat crop, especially in comparison with protein content; since sedimentation value replaced protein content as a basis for loan value premiums.

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For the past 15 years, the Doty Laboratories 4/ have made annual surveys of the quality of the U. S. hard red winter wheat crops, and for the past four years hard red spring wheat has been included in the surveys. For these surveys, samples were obtained from various areas of production shortly after harvest and were subjected to chemical and physical tests for quality including protein, milling, baking, and farinograph tests. Sedimentation tests were made in connection with this survey for the first time in 1961 and were made again in the 1962 crop survey.

For the 1962 survey, 2644 samples of hard red winter wheat and 947 samples of hard red spring wheat were obtained, making a total of 3591 samples. The winter wheat samples were obtained from 21 defined areas of production including all important wheat producing areas of Texas, Oklahoma, Kansas, Colorado, Nebraska, Wyoming, South Dakota, and Montana. The spring wheat samples were obtained from 10 areas of production in South Dakota, North Dakota, Minnesota, and Montana. Samples were obtained from numerous points of origin within the individual areas of production, and, for the most part, were obtained from trucks of wheat being delivered from farms to country elevators.

METHODS

Protein determinations and wheat sedimentation tests were made by the methods prescribed in the Sixth Edition of Cereal Laboratory Methods 5/. The Allis-Chalmers experimental flour mill was used for milling, and straight grade flours were used for the bread-baking and farinograph tests.

Bread-baking tests were made by a straight dough procedure using a modified AACC formula as follows:

200 g. flour	3 g. salt
10 g. sugar	1 g. malt flour
5 g. compressed years	2-6 mg. potassium bromate
4 g. hydrogenated shortening	

In preparing the doughs, the amount of water added was based on the water absorption value as determined by the farinograph plus 2 percent. Some adjustment in the amount of water added was made when it was obvious that proper dough consistency was not obtained by this formula. The doughs were mixed to optimum consistency in a Swanson-type mixer. They were fermented for three hours at 86° F., and 90 percent

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4/ The mention of firm names or trade products in this publication is for identification only and does not imply endorsement by the U. S. Department of Agriculture over other firms and products not mentioned.

5/ American Association of Cereal Chemists, Inc., Cereal Laboratory Methods, 6th Edition, Minneapolis: Lund Press, 1957.

relative humidity during which time they were punched after 105 minutes and again after an additional 50 minutes. At the end of the fermentation period, the doughs were molded, panned, and baked for 20 minutes at 420° F.

To obtain an overall quality evaluation, a numerical "flour evaluation score" was determined for each sample of wheat. This score is designed to reflect the relative suitability of the flour milled from the wheat for bread production. It is based on bread-baking quality (bread score), dough handling properties, mixing strength as determined by the farinograph, and the ratio of bread-loaf volume to protein content. Primary emphasis is on bread score. Sedimentation value is not included among the factors used to calculate the flour evaluation score.

"Flour evaluation score" is computed in the following manner:

Bread score:	
Loaf volume	25 points maximum
Crust character	3 points maximum
Crumb grain	20 points maximum
Crumb texture	20 points maximum
Crumb color and aroma	7 points maximum
Total bread score	75 points maximum
Dough handling properties	5 points maximum
Mixing strength (farinograph peak time)	10 points maximum
Loaf volume: protein ratio	10 points maximum
Flour Evaluation Score	100 points maximum

STATISTICAL ANALYSIS OF DATA

All data on 20 percent of the samples tested from each of the 31 areas of production were furnished by the Doty Laboratories to the U. S. Department of Agriculture for statistical analysis. These samples were selected essentially in a random manner, except that care was taken to include at least one sample from each point of origin within each area or production and also to include samples covering as nearly as possible the entire range of quality in respect to the various factors of quality measured.

Mean values for sedimentation value, protein content, the various farinogram characteristics, and "flour evaluation score" for each of the 31 areas of production are recorded in Table 1.

Table 2 shows the minimum, maximum, and mean values by class for all factors considered in this study. It is quite apparent that for each of the two classes of wheat, all factors covered rather wide ranges in value.

Mixing time, mixing tolerance, water absorption, mixing tolerance index (M.T.I.), and valorimeter value all as determined by means of the farinograph as well as protein content are all recognized as important indexes of baking strength. The correlations between each of these factors and flour evaluation score were therefore determined for each area of production. The correlation between wheat sedimentation value and flour evaluation score for each area was also determined to ascertain how well sedimentation compared in reliability with the other factors as an index of baking strength. The correlation coefficients by area of production for hard red winter wheat and hard red spring wheat are shown in Tables 3 and 4, respectively, and by class for all areas combined in Table 5.

Selection of wheat by the milling industry is frequently based in large part on farinogram characteristics, since these characteristics are believed to provide a more reliable guide to quality than does protein content. It is of interest, therefore, to know whether protein content or sedimentation value correlates more highly with the various farinogram characteristics. The pertinent correlation coefficients are shown in Tables 6, 7, and 8.

RESULTS

The correlation between wheat sedimentation value and flour evaluation score was higher than the correlation between wheat protein content and flour evaluation score in 18 of the 21 hard red winter wheat areas of production and in all of the 10 hard red spring wheat areas. The superiority of sedimentation over protein was quite great in most of the areas, especially in the case of hard red spring wheat.

Sedimentation also correlated more highly with flour evaluationn score than did either mixing time, mixing tolerance, water absorption, M.T.I., or valorimeter value in a large majority of the areas. The superiority of sedimentation over the various farinogram characteristics was quite marked in most instances.

Statistically, it was found that for the winter wheat areas combined, the spring wheat areas combined, and all areas combined (Table 5), the superiority of sedimentation over protein and over each of the farinogram characteristics as a measure of flour evaluation score was significant

at the 99 percent level. This means that we can be 99 percent confident that the higher correlations obtained for sedimentation are due to its actual superiority over protein and over the farinogram characteristics as a measure of bread-baking quality, and that when this large a sampling of the crop is considered, incorrect conclusions would be drawn only once in 100 times.

In a great majority of the 31 areas of production, sedimentation correlated more highly than protein with most of the important farinogram characteristics, including mixing time, mixing tolerance, M.T.I., and valorimeter value. Only as a measure of water absorption did sedimentation fail to show an important superiority over protein.

In comparing the relationships of several variable factors with a single factor, it is common practice to use the squares of the correlation coefficients (r^2 values) rather than correlation coefficients themselves (r values) as the basis for comparison. Applying this system to the flour evaluation score data by classes (see Table 5), the r^2 values are shown in Table 9.

The r^2 values in Table 9 indicate the part of the variability in flour evaluation score that can be accounted for by the various factors with which flour evaluation score was compared. Thus, for example, in hard red winter wheat 83 percent of the variability in flour evaluation score could be accounted for by sedimentation value, but only 50 percent by protein content. The corresponding figures for hard red spring wheat are 59 percent for sedimentation and only 21 percent for protein.

Table 1.--Mean values for sedimentation value, protein content, the various farinogram characteristics, and flour evaluation score by area of production

Area of production		No. of samples	Wheat		Flour-farinogram characteristics					Flour evaluation score
No.	Name		Sed. value	Prot. 1/	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value	
				Pct.	Min.	Min.	Pct.			
				HARD RED WINTER WHEAT						
1	Texas (except panhandle)	32	43.8	12.4	4.2	10.6	57.4	53.9	57.2	81.8
2	S. W. Oklahoma	35	42.2	11.3	4.2	9.2	55.9	58.4	56.3	80.5
3	N. W. Oklahoma	34	47.8	11.6	4.4	9.4	56.7	45.6	57.1	83.9
4	Texas-Oklahoma panhandle	33	49.1	12.0	5.9	13.8	58.5	39.4	58.0	85.4
5	S. E. Colorado	18	49.6	12.7	3.4	10.5	58.5	42.5	54.3	83.5
6	S. W. Kansas	36	48.6	12.1	5.3	9.9	57.7	38.1	59.9	83.9
7	S. E. Kansas	20	46.4	11.4	4.2	10.6	55.6	42.2	56.8	81.1
8	W. Central Kansas	36	47.8	11.6	4.6	9.3	56.9	43.6	59.1	83.1
9	E. Central Kansas	18	50.6	11.8	5.0	10.1	56.5	40.3	60.0	84.7
10	N. W. Kansas	30	47.8	11.1	4.8	9.5	56.3	43.2	53.9	84.4
11	N. E. Kansas	14	47.1	11.5	4.3	9.9	57.0	40.4	57.9	81.6
12	N. E. Colorado	22	45.4	11.9	4.3	9.0	58.1	48.2	56.6	82.3
13	S. W. Nebraska	29	42.2	11.1	4.7	8.6	58.6	45.5	55.1	82.6
14	S. E. Nebraska	20	45.9	11.4	4.2	8.9	56.4	42.8	55.7	81.8
15	Nebraska panhandle	30	37.6	10.5	5.0	9.1	56.8	42.7	50.2	80.5
16	N.Central Nebraska	28	40.9	11.0	5.1	8.0	58.3	46.3	52.4	82.8
17	N.E. Nebraska	18	43.0	11.4	4.4	9.8	57.8	40.8	51.3	80.3
18	S.E. Wyoming	14	41.7	11.3	5.5	8.7	57.2	48.6	51.2	80.5
19	N.E. Wyoming	15	43.3	10.9	5.6	8.6	57.1	47.3	52.4	80.6
20	S.W. South Dakota	32	38.2	11.2	4.6	8.0	57.6	44.4	50.6	76.8
21	S. Montana	19	60.8	12.2	6.2	11.1	60.4	40.8	59.5	90.6
All HRW areas combined		533	45.4	11.5	4.8	9.7	57.4	44.8	55.7	82.5

Table 1.--Mean values for sedimentation value, protein content, the various farinogram characteristics, and flour evaluation score by area of production--continued

Area of production		No. of samples	Wheat		Flour-farinogram characteristics					Flour evaluation score
No.	Name		Sed. value	Prot. 1/	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value	
				Pct.	Min.	Min.	Pct.			
			HARD RED SPRING WHEAT							
1	S.E. South Dakota	21	50.7	13.5	5.4	9.0	61.6	38.1	61.3	90.1
2	N.W. South Dakota	10	60.0	14.2	5.3	9.6	64.2	32.5	61.0	91.4
3	N.E. South Dakota	22	60.8	13.5	6.3	13.7	62.5	22.5	66.8	93.6
4	Minnesota	26	60.2	12.7	5.5	9.5	62.3	36.0	60.0	91.0
5	E. Montana	18	63.7	14.0	5.2	8.9	62.7	31.4	62.1	94.3
6	S.W. North Dakota	17	60.1	13.5	5.0	8.3	65.4	34.7	60.2	91.6
7	S.E. North Dakota	22	61.4	13.6	5.1	9.3	63.5	36.4	61.0	92.1
8	N.W. Montana	10	65.2	14.2	6.2	11.0	63.6	29.5	65.8	95.3
9	N.W. North Dakota	20	68.0	13.7	5.9	11.4	65.9	25.5	66.2	93.7
10	N.E. North Dakota	20	65.3	13.4	5.4	9.7	62.8	31.0	62.9	90.4
All HRS areas combined		186	61.3	13.5	5.5	10.1	63.3	31.9	62.6	92.2
All HRW and HRS areas combined		719	49.6	12.1	5.0	9.8	58.9	41.5	57.5	85.0

1/ 14.0 percent moisture basis.

Table 2.--Range and mean values of sedimentation, protein, farinogram characteristics, and "flour evaluation score" for all hard red winter wheat areas combined and all hard red spring wheat areas combined

Factor	Hard Red Winter Wheat (533 samples)			Hard Red Spring Wheat (186 samples)		
	Min.	Max.	Mean	Min.	Max.	Mean
Sedimentation value	17	74	45.4	37	72	61.3
Protein, pct. 1/	8.2	15.3	11.5	11.4	16.1	13.5
Mixing time, min.	1.5	19.5	4.8	3.8	12.2	5.5
Mixing tolerance, min.	3.0	27.8	9.7	4.5	26.5	10.1
Water absorption, pct.	49.5	64.5	57.4	57.5	69.2	63.3
Mixing tolerance index (MTI)	10	85	44.8	10	70	31.9
Valorimeter value.....	33	83	55.7	50	85	62.6
Flour evaluation score.....	60	98	82.5	81	98	92.2

1/ 14.0 percent moisture basis.

Table 3.--Correlation coefficients. Various factors vs. "flour evaluation score." Hard red winter wheat, by area of production

Area of production		No. of samples	Wheat		Flour - farinogram characteristics				
No.	Name		Sed. value	Protein 1/	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value
1	Texas (except panhandle)	32	.87	.67	.85	.64	.77	-.78	.92
2	S. W. Oklahoma	35	.95	.65	.73	.83	.63	-.80	.93
3	N. W. Oklahoma	34	.90	.36	.75	.74	.49	-.94	.98
4	Texas-Okla. panhandle	33	.95	.89	.68	.76	.88	-.88	.95
5	S. E. Colorado	18	.90	.61	.84	.89	.71	-.85	.89
6	S. W. Kansas	36	.90	.89	.85	.87	.81	-.81	.90
7	S. E. Kansas	20	.96	.79	.89	.79	.79	-.82	.96
8	W. Central Kansas	36	.95	.70	.77	.74	.76	-.86	.95
9	E. Central Kansas	18	.98	.87	.94	.87	.86	-.94	.97
10	N. W. Kansas	30	.97	.87	.87	.86	.92	-.88	.90
11	N. E. Kansas	14	.97	.84	.67	.75	.72	-.69	.64
12	N. E. Colorado	22	.92	.85	.89	.83	.89	-.92	.95
13	S. W. Nebraska	29	.98	.92	.77	.81	.89	-.86	.94
14	S. E. Nebraska	20	.88	.91	.76	.82	.91	-.88	.91
15	Nebraska panhandle	30	.95	.92	.79	.66	.82	-.76	.92
16	N. Central Nebraska	28	.94	.94	.85	.76	.81	-.79	.87
17	N. E. Nebraska	18	.94	.90	.89	.88	.90	-.93	.95
18	S. E. Wyoming	14	.94	.90	.95	.84	.95	-.91	.94
19	N. E. Wyoming	15	.95	.96	.76	.81	.54	-.95	.92
20	S. W. South Dakota	32	.98	.88	.86	.80	.84	-.79	.87
21	S. Montana	19	.97	.85	.74	.73	.84	-.82	.89

1/ 14.0 percent moisture basis.

Table 4.--Correlation coefficients. Various factors vs. "flour evaluation score." Hard red spring wheat, by area of production

Area of production		No. of samples	Wheat		Flour - farinogram characteristics				
No.	Name		Sed. value	Protein 1/	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value
1	S.E. South Dakota	21	.89	.53	-.22	-.45	.58	.43	-.39
2	N.W. South Dakota	10	.91	.65	-.05	-.16	.56	.19	-.25
3	N.E. South Dakota	22	.88	.61	.69	.49	.02	-.70	.68
4	Minnesota	26	.96	.79	.56	.48	.89	-.71	.67
5	E. Montana	18	.79	.07	.75	.55	.35	-.50	.78
6	S.W. North Dakota	17	.91	.28	.62	.60	.17	-.55	.62
7	S.E. North Dakota	22	.86	.27	.61	.36	-.02	-.69	.75
8	N.W. Montana	10	.81	.75	.81	.75	.67	-.80	.84
9	N.W. North Dakota	20	.89	.63	.75	.36	.35	-.47	.59
10	N.E. North Dakota	20	.92	.13	.69	.72	-.01	-.33	.77

1/ 14.0 percent moisture basis.

Table 5.--Correlation coefficients. Various factors vs. "flour evaluation score." All hard wheat, by class

Class	No. of areas	No. of samples	Wheat		Flour - Farinogram characteristics				
			Sedimentation value	Protein 1/	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value
HRW	21	533	.91	.71	.74	.72	.74	-.78	.86
HRS	10	186	.77	.46	.54	.42	.36	-.51	.58
HRW & HRS	31	719	.93	.74	.70	.60	.77	-.78	.85

1/ 14.0 percent moisture basis.

Table 6.--Correlation coefficients. Wheat sedimentation, wheat protein, and farinogram characteristics. Hard red winter wheat, by area of production

Area of production		No. of samples	Mixing time vs.		Mixing tolerance vs.		Water absorption vs.		M.T.I. vs.		Valorimeter value vs.		Sedimentation vs.
No.	Name		Sed.	Prot. 1/	Sed.	Prot. 1/	Sed.	Prot. 1/	Sed.	Prot. 1/	Sed.	Prot. 1/	Protein 1/
1	Texas (except panhandle)	32	.92	.64	.86	.49	.82	.74	-.88	-.52	.95	.65	.67
2	S. W. Oklahoma	35	.79	.73	.85	.63	.67	.94	-.79	-.81	.95	.69	.68
3	N. W. Oklahoma	34	.70	.30	.68	.22	.74	.91	-.83	-.26	.90	.32	.64
4	Texas-Okla. panhandle	33	.65	.59	.66	.64	.89	.83	-.83	-.75	.99	.94	.94
5	S. E. Colorado	18	.85	.47	.81	.50	.69	.69	-.85	-.57	1.00	.71	.72
6	S. W. Kansas	36	.91	.84	.93	.83	.89	.96	-.91	-.84	.99	.89	.90
7	S. E. Kansas	20	.85	.73	.74	.59	.80	.72	-.81	-.68	.99	.78	.77
8	West Central Kansas	36	.77	.56	.74	.52	.68	.88	-.87	-.61	.99	.66	.66
9	East Central Kansas	18	.94	.83	.90	.84	.88	.83	-.90	-.85	.96	.89	.89
10	N. W. Kansas	30	.89	.80	.86	.79	.92	.91	-.88	-.83	.92	.88	.90
11	N. E. Kansas	14	.61	.61	.73	.66	.72	.85	-.61	-.53	.55	.55	.89
12	N. E. Colorado	22	.80	.69	.76	.65	.82	.77	-.83	-.71	.86	.76	.90
13	S. W. Nebraska	29	.80	.72	.86	.77	.92	.87	-.88	-.85	.96	.89	.92
14	S. E. Nebraska	20	.59	.72	.68	.77	.92	.94	-.71	-.81	.75	.85	.95
15	Nebraska panhandle	30	.83	.76	.73	.68	.81	.82	-.76	-.70	.95	.91	.94
16	N. Central Nebraska	28	.85	.82	.79	.71	.81	.86	-.83	-.75	.85	.78	.93
17	N. E. Nebraska	18	.93	.78	.91	.77	.89	.89	-.89	-.82	.82	.82	.91
18	S. E. Wyoming	14	.91	.79	.79	.70	.91	.96	-.85	-.77	.88	.80	.87
19	N. E. Wyoming	15	.90	.74	.93	.78	.39	.55	-.94	-.89	.96	.87	.93
20	S. W. South Dakota	32	.89	.87	.85	.88	.88	.92	-.82	-.81	.89	.84	.92
21	S. Montana	19	.73	.86	.73	.88	.82	.92	-.81	-.83	.87	.86	.83

1/ 14.0 percent moisture basis.

Table 7.--Correlation coefficients. Wheat sedimentation, wheat protein, and farinogram characteristics. Hard red spring wheat, by area of production.

Area of production		No. of samples	Mixing time vs.		Mixing tolerance vs.		Water absorption vs		M.T.I. vs.		Valorimeter value vs.		Sed. vs.
No.	Name		Sed.	Protein 1/	Sed.	Protein 1/	Sed.	Protein 1/	Sed.	Protein 1/	Sed.	Protein 1/	Protein 1/
1	S. E. South Dakota	21	-.36	.11	-.62	-.29	.49	.33	.58	.10	-.50	-.11	.46
2	N. W. South Dakota	10	-.15	-.03	-.31	-.13	.45	.70	.42	.24	-.37	-.10	.67
3	N. E. South Dakota	22	.67	.65	.50	.43	.05	-.02	-.63	-.26	.66	.56	.71
4	Minnesota	26	.46	.43	.39	.35	.94	.85	-.68	-.57	.62	.63	.83
5	E. Montana	18	.27	.03	.11	-.33	.01	.61	-.29	.22	.36	-.11	.09
6	S. W. North Dakota	17	.60	.28	.47	-.27	.37	.65	-.37	.46	.56	-.29	.46
7	S. E. North Dakota	22	.39	.17	.07	-.49	.08	.29	-.54	.15	.58	.00	.54
8	N. W. Montana	10	.57	.66	.47	.57	.87	.76	-.51	-.57	.59	.69	.84
9	N. W. North Dakota	20	.65	.51	.17	-.09	.38	.57	-.35	-.13	.55	.37	.78
10	N. E. North Dakota	20	.74	.23	.73	.18	.14	.49	-.45	-.11	.82	.29	.06

1/ 14.0 percent moisture basis.

Table 8.-- Correlation coefficients. Wheat sedimentation, wheat protein, and farinogram characteristics. All hard wheat, by class

Class	No. of areas	No. of samples	Mixing time vs.		Mixing tolerance vs.		Water absorption vs.		M.T.I. vs.		Valorimeter value vs.		Sed. vs.
			Sed.	Protein 1/	Sed.	Protein 1/	Sed.	Protein 1/	Sed.	Protein 1/	Sed.	Protein 1/	Protein 1/
HRW	21	533	.71	.54	.74	.61	.73	.75	-.77	-.60	.89	.73	.78
HRS	10	186	.36	.26	.28	.06	.46	.43	-.40	-.07	.44	.24	.42
HRW & HRS	31	719	.65	.47	.58	.42	.79	.77	-.76	-.58	.85	.68	.77

1/ 14.0 percent moisture basis.

Table 9.--Relation of various factors to "flour evaluation score" in terms of r^2 values.

Factor	r^2 values		
	HRW	HRS	HRW and HRS combined
Sedimentation (wheat)	.83	.59	.86
Protein (wheat) 1/	.50	.21	.55
Mixing time	.55	.29	.49
Mixing tolerance	.52	.18	.36
Water absorption	.55	.13	.59
M.T.I.	.61	.26	.61
Valorimeter value	.74	.34	.72

1/ 14.0 percent moisture basis.